Reaction Plane Task Force Status Report

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In-official "Task Force" of people studying issues with the RxNP sub-event distribution and subtleties of estimating event plane resolution:

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N. N. Ajitanand, A. Taranenko, R. Wei, R. Lacey (SUNY Stony Brook)
Yoshimasa Ikeda, Hiroshi Masui, ShinIchi Esumi (Tsukuba)

2 meetings:

https://www.phenix.bnl.gov/cdsagenda//fullAgenda.php?ida=a08450

https://www.phenix.bnl.gov/cdsagenda//fullAgenda.php?ida=a08336

Tony asked me to give a short status report, here it is.

Outline

-> What's the problem?

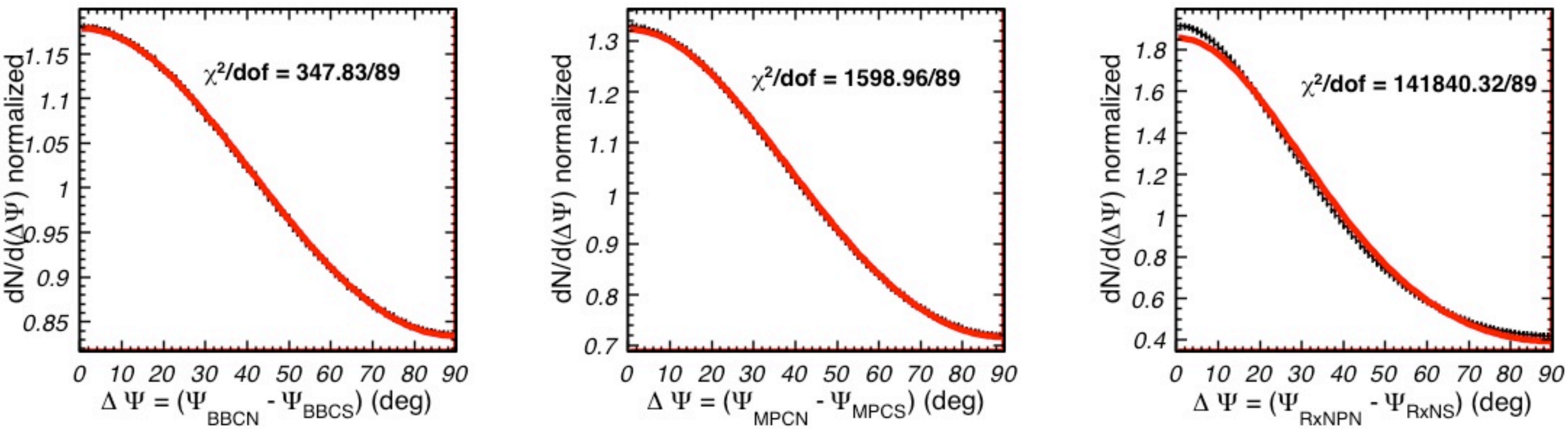
-> Some obvious (but unimportant as it turns out) candidates
(shown here mainly to put you at ease :-)

-> The real issues (direct correlations and detector effects)

-> The path forward (improved sub-event fitting method)

-> To-do list

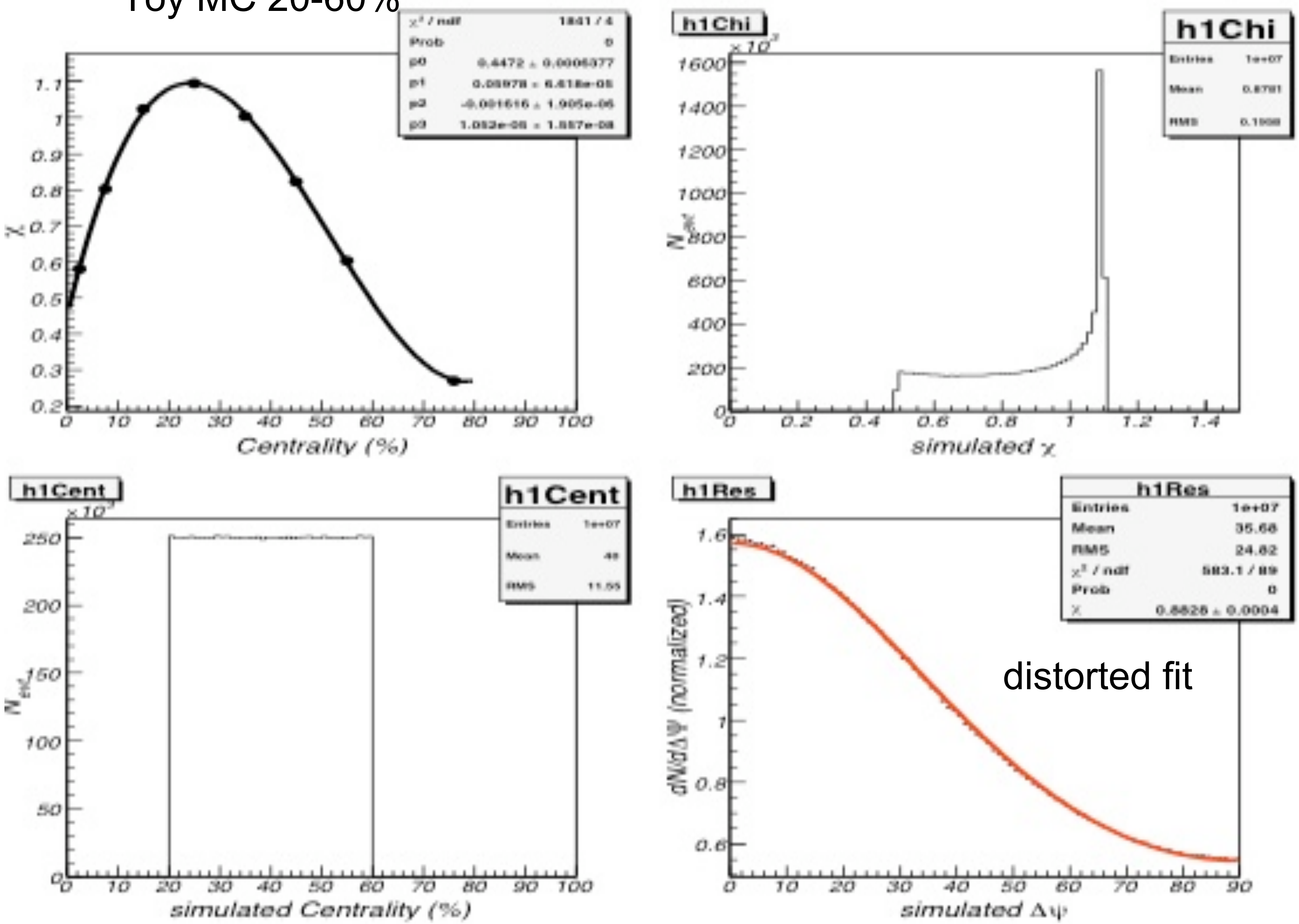
What's the problem



RxNP (and MPC) sub-event distributions do not follow a harmonic assumption. This may pose a problem when estimating the event Plane resolution (since this is done using the relative angle between 2 or more sub-events)

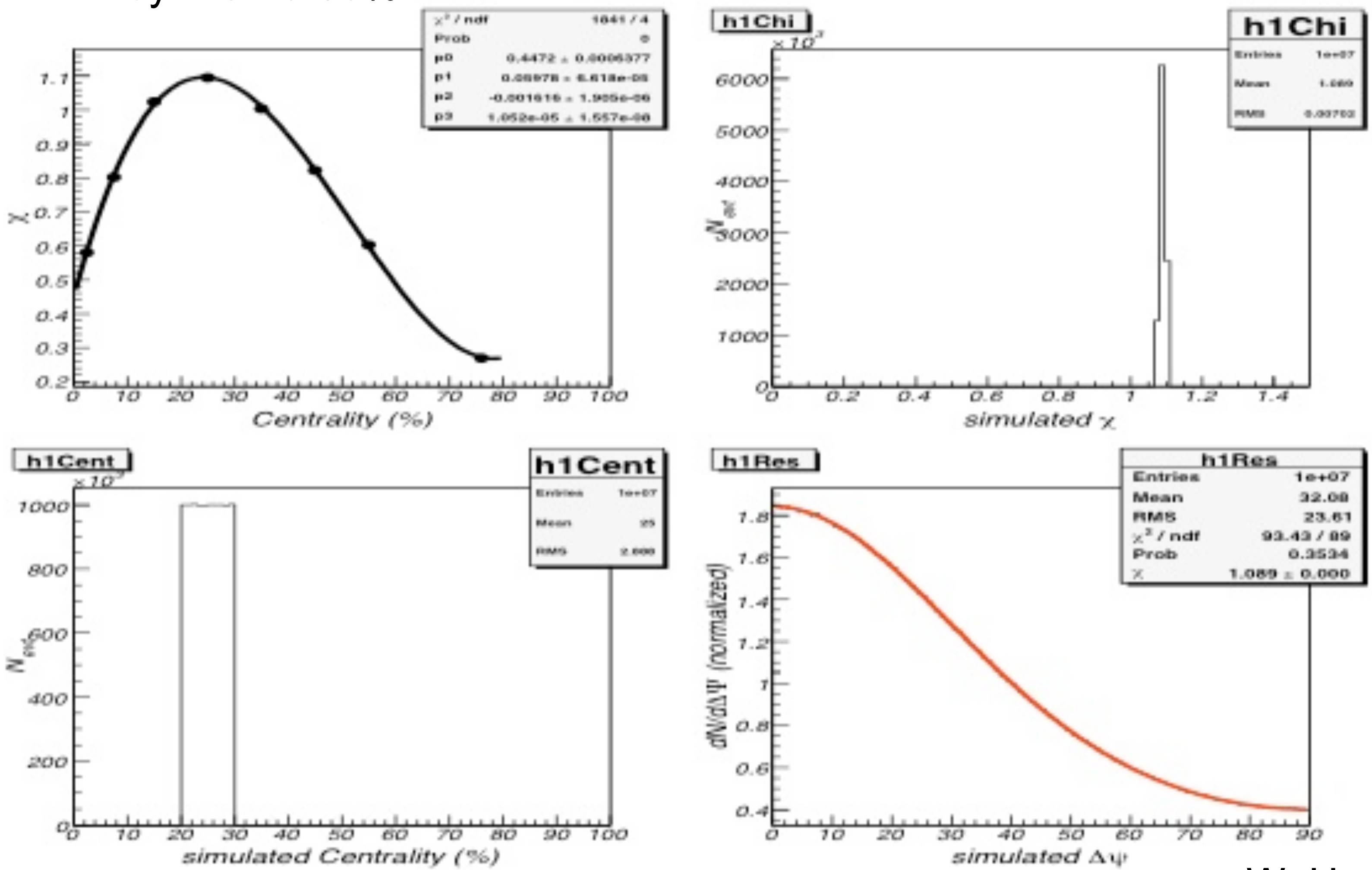
Possible candidate: centrality binning

Toy MC 20-60%



Possible candidate: centrality binning

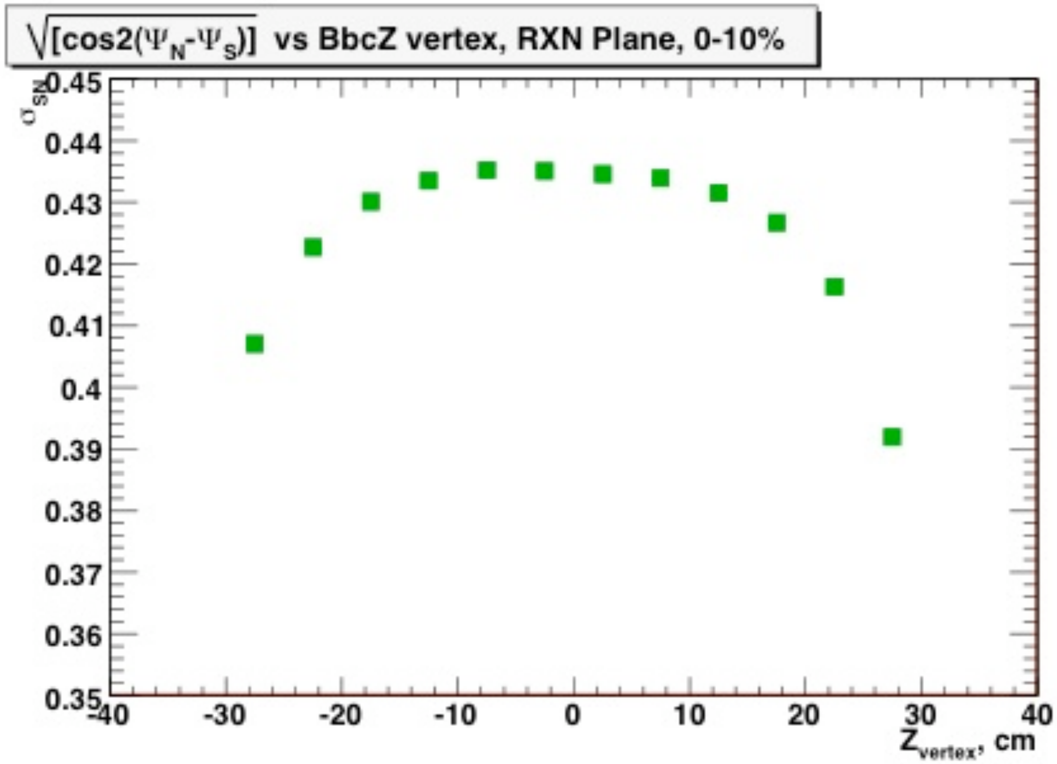
Toy MC 20-30%



W. H.

Not an issue if centrality binning <= 10% steps
(standard for PHENIX reaction plane analyses)

Possible candidate: vertex binning

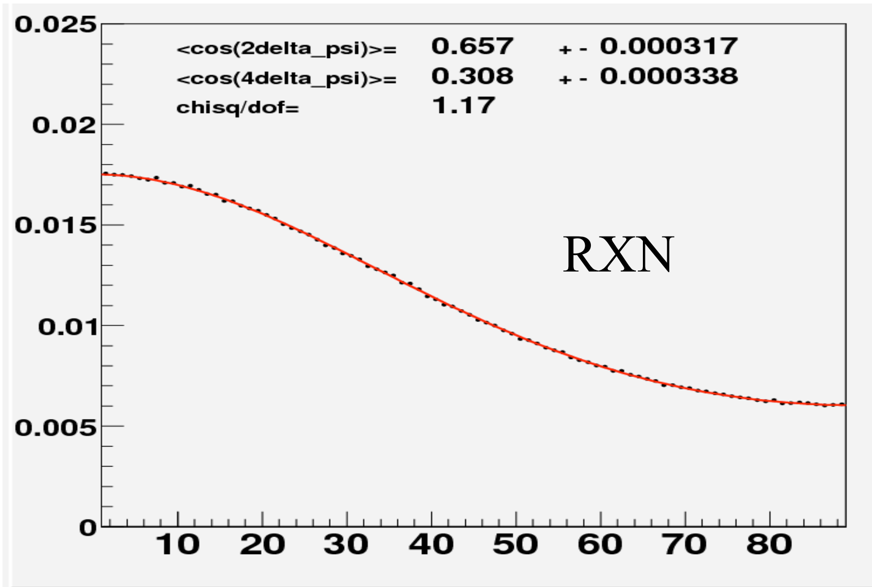


A. Taranenko

Effect is small when vertex bins are averaged and weighted.

Possible candidate: v4

SIM Pure Flow (v2 and v4 = v2*v2) 5 million events



Simulation studies
N. N. Ajitanand

W. H: $$\frac{1}{Q_2}\frac{d^2N}{dQ_2 d\Delta\phi} = \frac{1}{4\pi\sigma_x\sigma_y} exp\left(-\frac{(Q_2 cos(2\Delta\phi) - \langle Q_{2,x}\rangle)^2}{2\sigma_x^2} - \frac{Q_2^2 sin^2(2\Delta\phi)}{2\sigma_y^2}\right)$$

where for the fluctuations one gets (assuming unit weights for simplicity) [?]

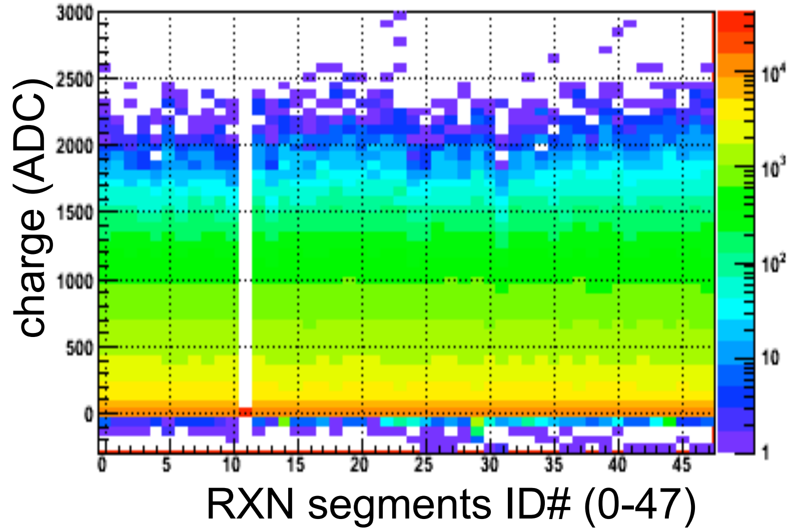
$$\sigma_x^2 = N(\langle cos^2(2\phi)\rangle - \langle cos(2\phi)\rangle^2)$$
$$\sigma_y^2 = N\langle sin^2(2\phi)\rangle.$$

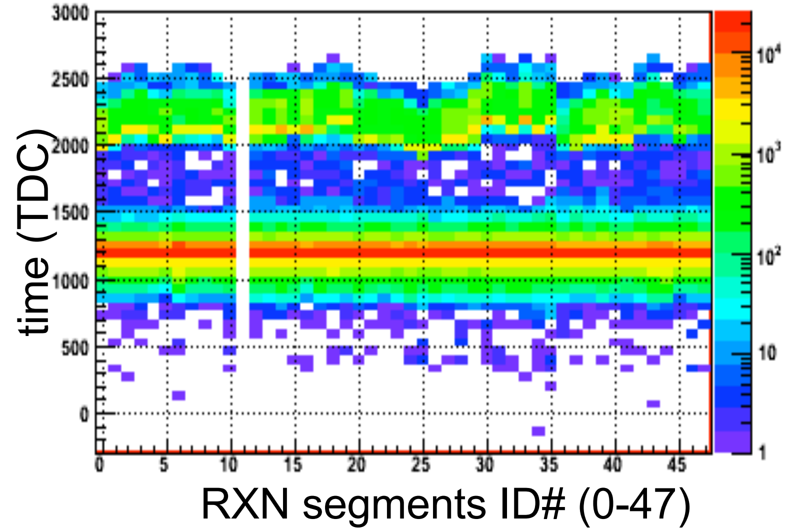
Recalling that $cos^2 x = (1 + cos2x)/2$ and $sin^2 x = (1 - cos2x)/2$ this can be rewritten as

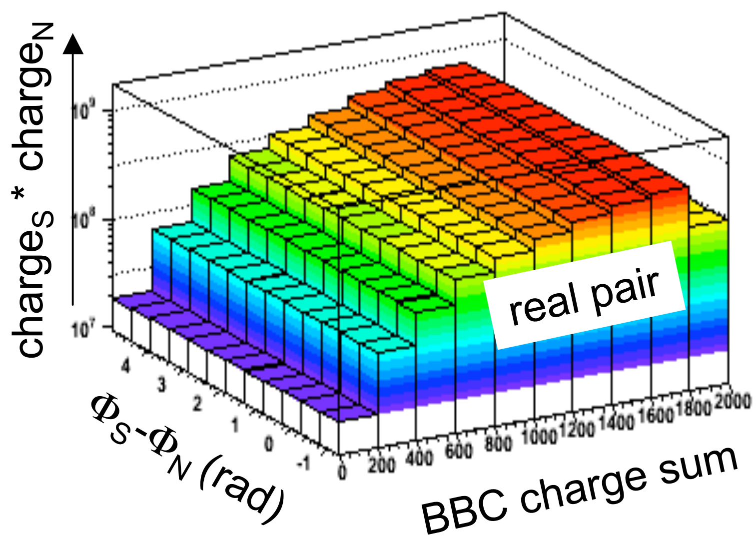
$$\sigma_x^2 = (N/2) \times (1 + \langle cos(4\Delta\phi)\rangle - 2\langle cos(2\Delta\phi)\rangle^2)$$
$$\sigma_y^2 = (N/2) \times (1 - \langle cos(4\Delta\phi)\rangle).$$

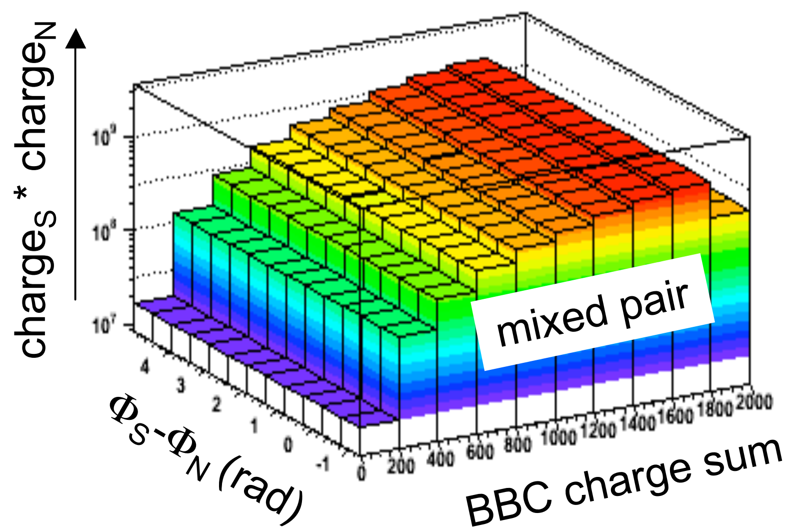
v4 is too small to have an appreciable effect on the sub-event distribution

Gaining further insight: RxNP correlations





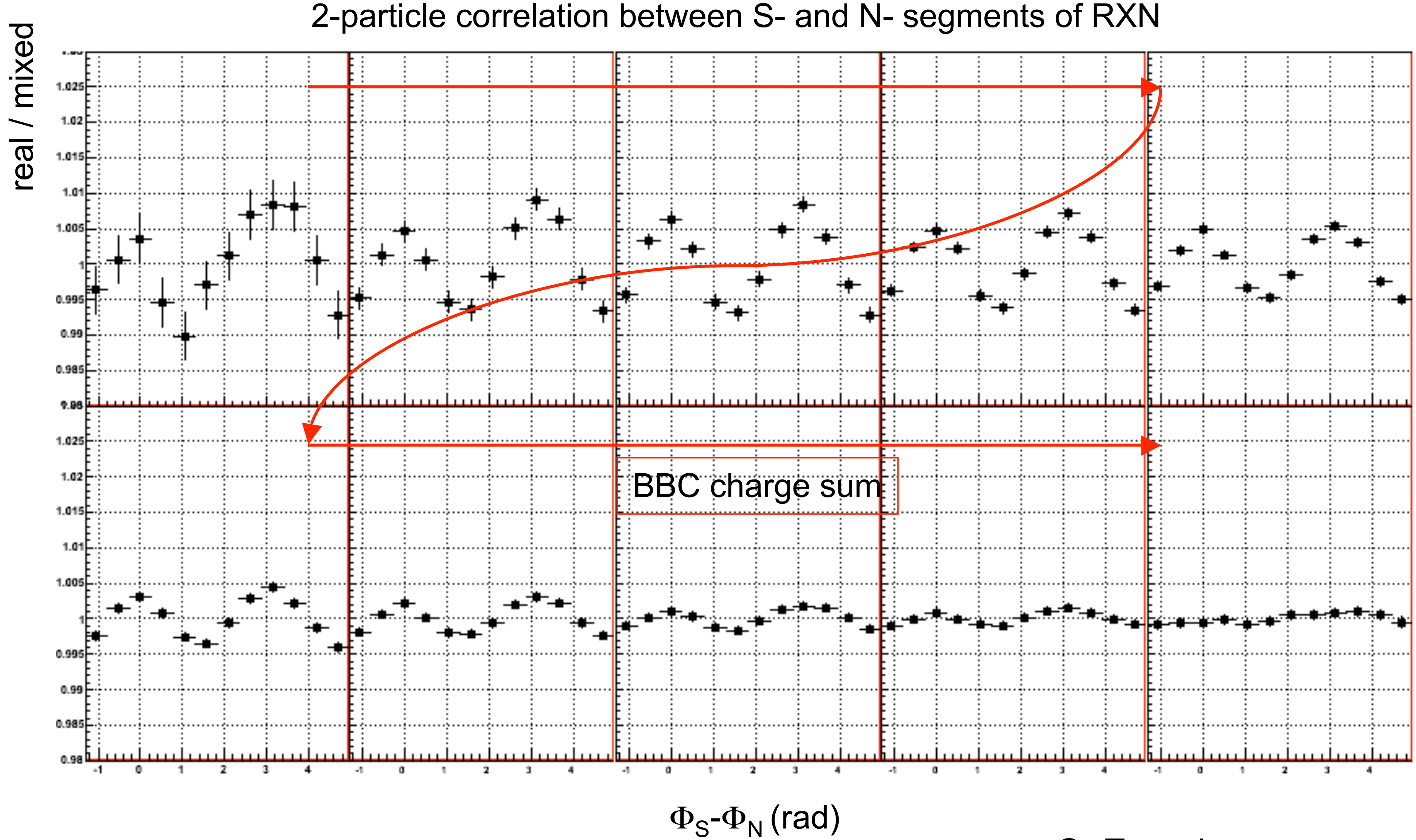




S. Esumi

Gaining further insight: RxNP correlations

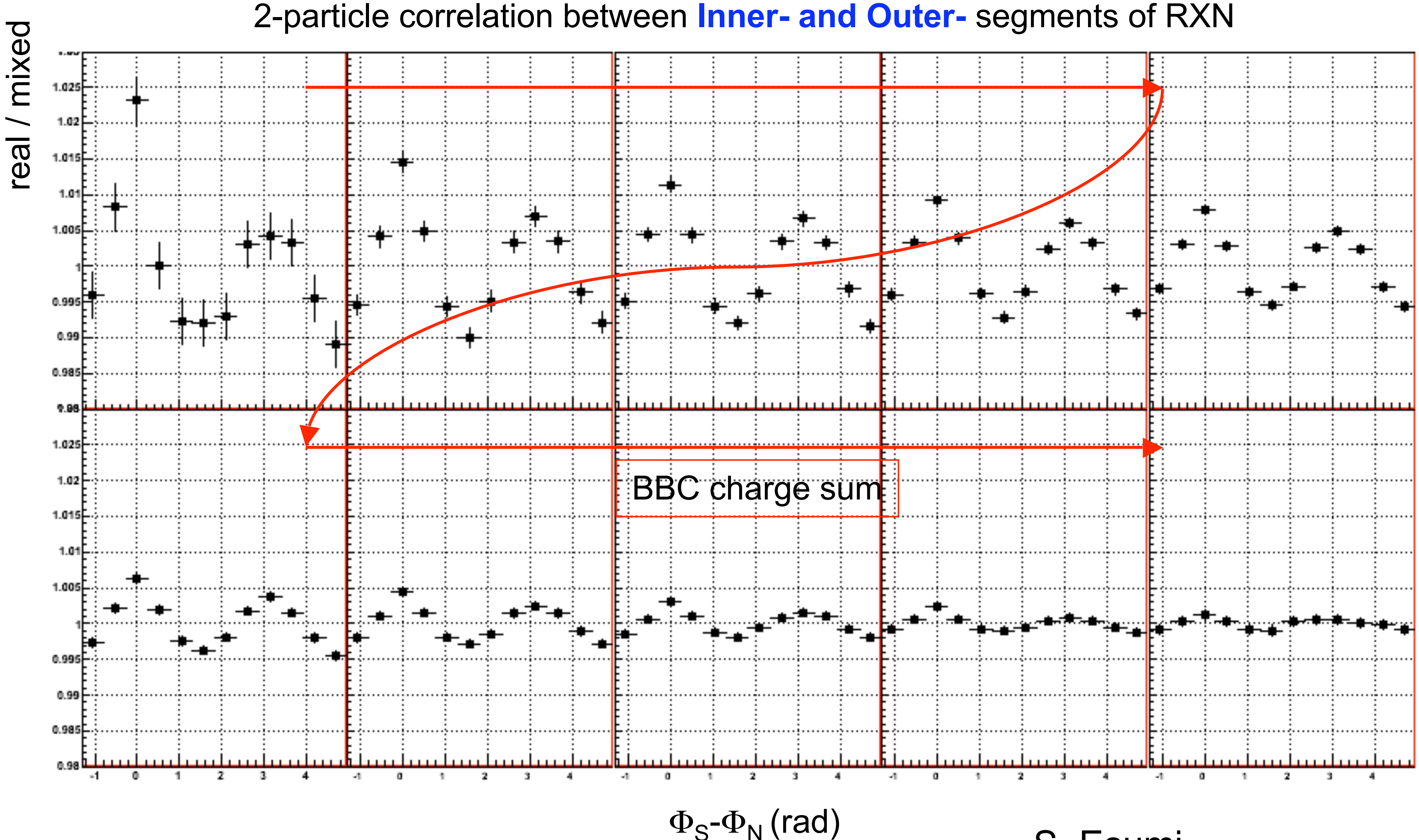
2-particle correlation between S- and N- segments of RXN



S. Esumi

Gaining further insight: RxNP correlations

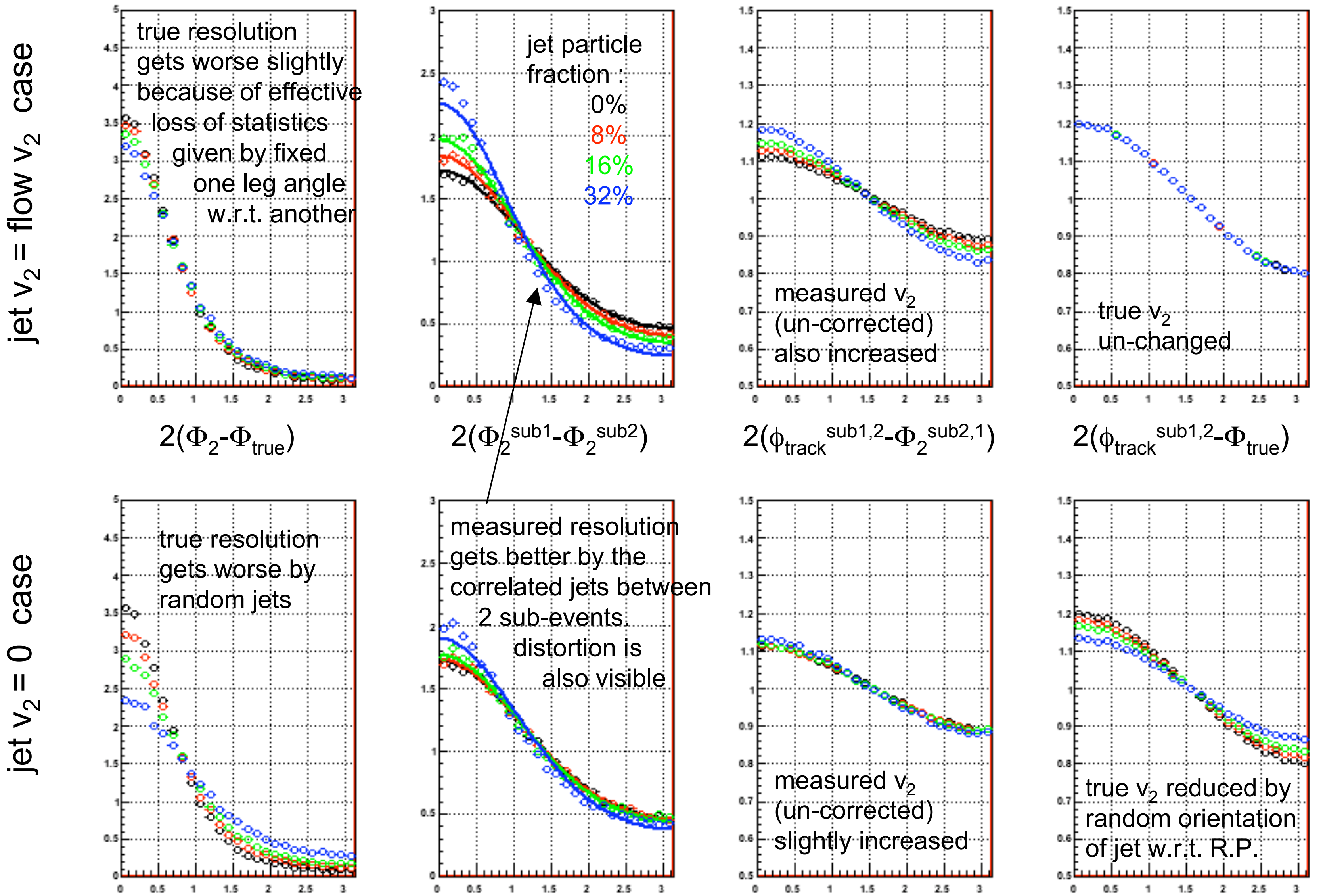
2-particle correlation between **Inner- and Outer-** segments of RXN



S. Esumi

pure flow + jet simulation

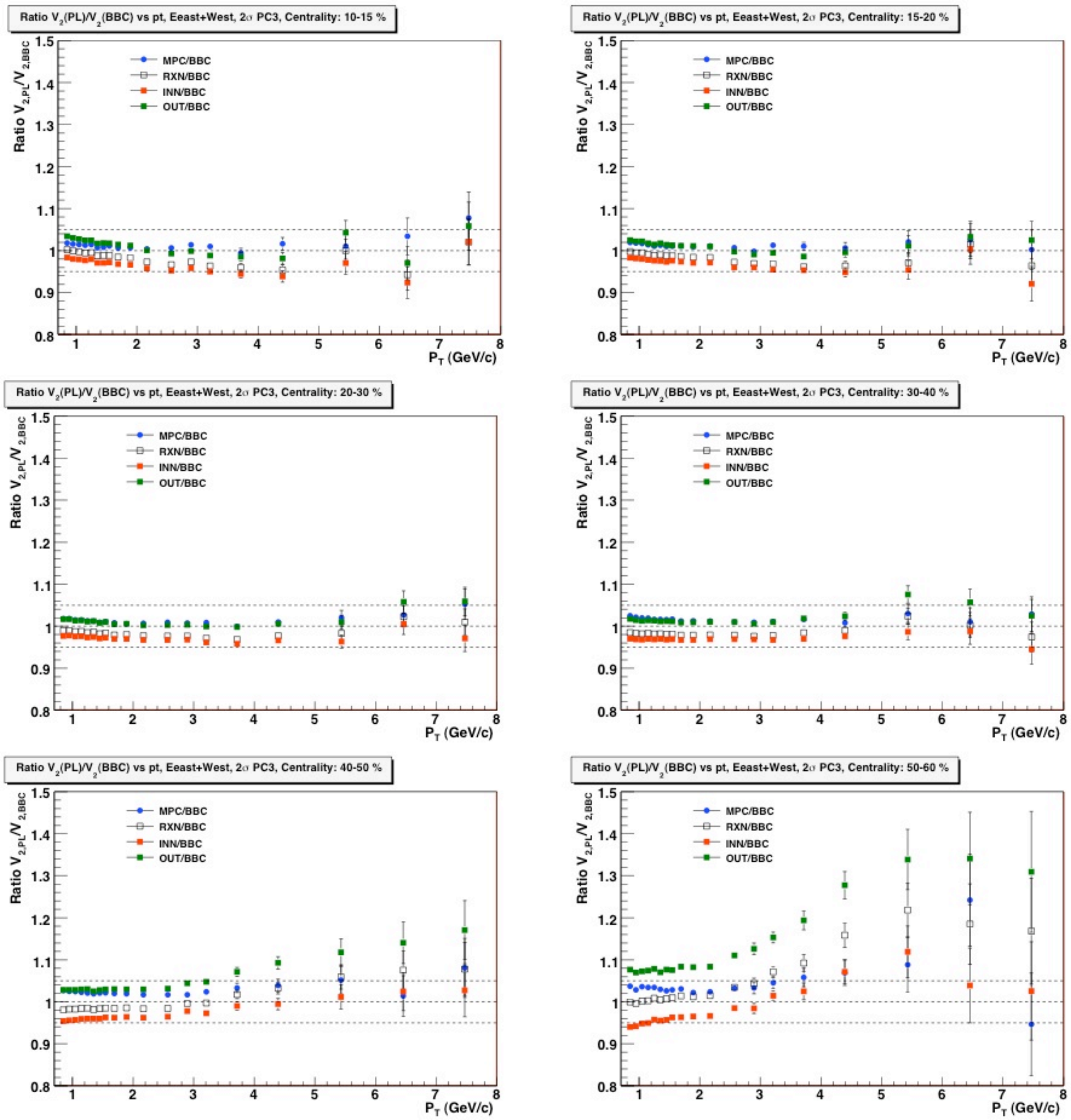
v_2=10%, v_1=v_3=v_4=0% fixed
back-to-back jet (2 particles) embedded
one leg in sub1, another leg in sub2



Discrepancy in pink circle shown in the
next page is given by this distortion.

S. Esumi

Gaining further insight:v2 comparisons



A. Taranenko

Both detector and non-flow effects are visible in v2. The non-flow only becomes important in peripheral events.

Improved Sub-event Fitting

Need fit function that combines the effects of flow, direct correlations and detector pathologies :

Lukasik and Trautmann have derived the joint probability distribution for Q-vectors from two random sub-events in the presence of direct correlations and non-equal fluctuations in x and y direction [1].

$$\frac{d^4N}{d\vec{Q}_A d\vec{Q}_B} = \frac{\exp\left(-\frac{(Q_{A,x}-\langle Q\rangle)^2+(Q_{B,x}-\langle Q\rangle)^2-2c(Q_{A,x}-\langle Q\rangle)(Q_{B,x}-\langle Q\rangle)}{\sigma_x^2(1-c^2)} - \frac{Q_{A,y}^2+Q_{B,y}^2-2cQ_{A,y}Q_{B,y}}{\sigma_y^2(1-c^2)}\right)}{\pi^2\sigma_x^2\sigma_y^2(1-c^2)} \quad (1)$$

J. Lukasik and W. Trautmann, (2006), nucl-ex/0603028

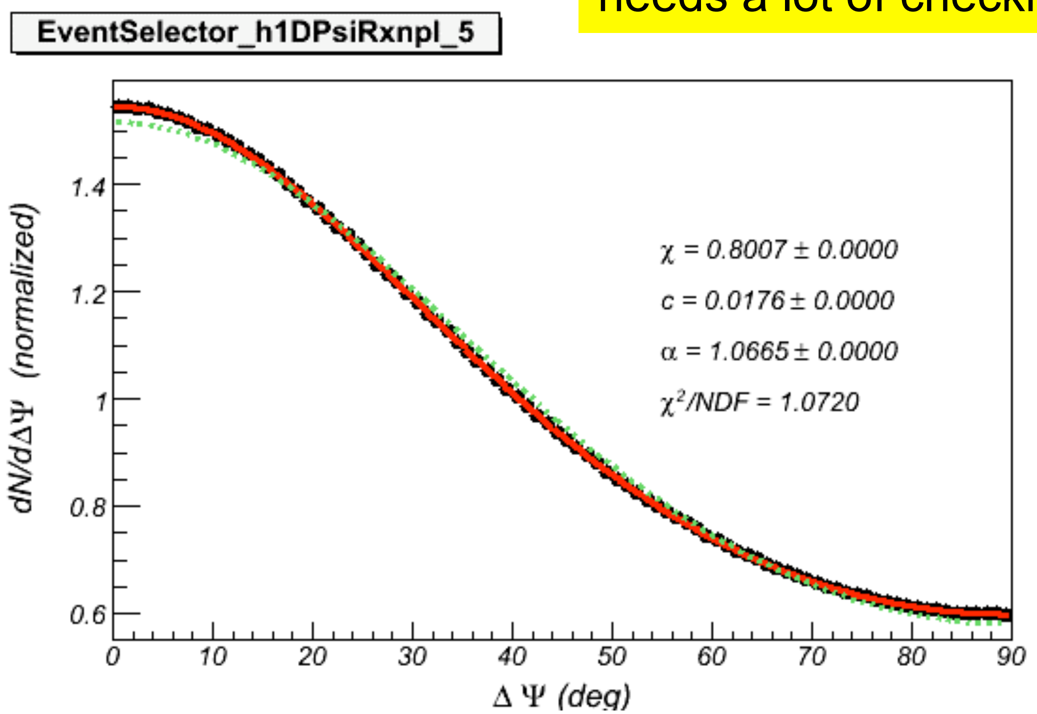
This can be integrated numerically to give the distribution in relative sub-event angle.

For the moment use the adaptive multidimensional fit algorithm of Genz and Malik:
A.C. Genz and A.A. Malik, J. Comput. Appl. Math. 6 (1980) 295-302

Example of Improved Sub-event Fitting

RxNPN-RxNPS cent=40-50%

Very preliminary, fit implementation still needs a lot of checking



W. H.

Fit can be further constrained:

$$\frac{\langle \vec{Q}_1 \cdot \vec{Q}_2 \rangle}{\langle Q_1^2 \rangle} \equiv \beta = \frac{\rho + \alpha^2(\rho + 2\chi_s^2)}{1 + \alpha^2(1 + 2\chi_s^2)}$$

Summary and Outlook

The distortion in the sub-event distribution can be understood in terms of direct correlations and detector effects. An improved fitting method by Lukasik and Trautmann has been adapted for PHENIX to account for these contributions.

To do:

-> check fitting output, see if it is reasonable (comparison SUNY / CU)

-> obtain all Q-vector dot products (table is being created)

-> write analysis note and be done with it

(estimated time-scale: 1-2 weeks max)